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The Concepts of Equilibrium Exchange Rate: A Survey of Literature

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Abstract

The aim of this paper is to review and examine a collection of 'most commonly applied' theoretical and empirical models of equilibrium exchange rate. The presentation on each model starts with an introduction of core theoretical frameworks. It will then be followed by discussions on relevant empirical steps to estimate the equilibrium rate. The rest of the paper will focus on assessing the strengths and weaknesses of the model and how each relates to the other.

Key Words: Equilibrium, Exchange Rate Models, PPP, Monetary Model, BEER, DEER, FEER, PEER and NATREX.

JEL Classifications: F31, F32

1. Introduction

The aim of this paper is to review and examine a collection of 'most commonly applied' theoretical and empirical models of equilibrium exchange rate. The presentation on each model starts with an introduction of core theoretical frameworks. It will then be followed by discussions on relevant empirical steps to estimate the equilibrium rate. The rest of the paper will focus on assessing the strengths and weaknesses of the model and how each relates to the other.

Since one of the principle objectives is also to examine the capacity of these models as tools to analyse topical policy issues/questions, it is therefore appropriate that a compilation of policy debates put forth by early studies be briefly summarised before discussion of any models. A similar line of reasoning was also presented in a recent work by Driver and Westaway (2004): "what matters when choosing between different equilibrium concepts (and the models that have been used to represent them) is their relevance to the question in hand" (page 9).

The structure of the paper is as follows. Section 2 introduces a number of policy debates which have motivated early studies on the equilibrium exchange rate. Section 3 presents basic measurement and definition of exchange rate. The focus, in particular, is on the construction of real (effective) exchange rate and its decomposition into tradable and non-tradable real exchange rate. In Sections 4-10, a selection of core theoretical and empirical models of equilibrium exchange rate are discussed, starting with Purchasing Power Parity, one of the oldest and arguably, most prominent model of equilibrium exchange rate. The paper ends with a brief concluding Section.

2. Policy Debates on 'Equilibrium' Rate and Exchange Rate Policy

A series of questions directly related to the underlying theoretical frameworks have been frequently posted in early studies in this area of research. Some of the most common ones are:

1) What are equilibrium exchange rates? What are the fundamentals? What does it mean for a currency to be misaligned?
2) Do real exchange rates revert to the mean? Are real exchange rates stationary in the long-run?
3) How important are the nominal shocks relative to real shocks in driving the changes in the real exchange rate?
4) How significant is the Balassa-Samuelson effect?
5) How important is the rise in the labour productivity in driving the movements of the real exchange rate? Does productivity growth lead to an appreciation of the local currency both in the medium- and long-term?

In addition, the estimation of equilibrium exchange rate also provides a vital measurement to address a much broader array of policy questions. In the wake of the 1997 financial crisis in East Asia, volumes of studies have been done to evaluate the

degree of misalignment of the local currencies (usually in a bilateral term against a major currency such as the US dollar or the Japanese yen).[1] Have the misalignments (or the deviations from the equilibrium rate) been brief and temporary? Or have they persisted? As will be further discussed in-depth, the issues of temporariness versus permanence underscore the need to break the analyses on the equilibrium exchange rate into medium and long-term horizons.

During the post-1997 crisis, a number of important views emerged to explain the rapid stockpiling of foreign exchange reserves by most East Asian economies, one of which is the mercantilist argument. This view claims that aside from the desire to maintain exchange rate predictability, reserve growth has been primarily motivated by desires of these countries to preserve an undervalued local currency and to enhance the international competitiveness of newly emerging industries (Dean and Rajan (2004)). In the context of China, Dooley, Folkerts-Landau, and Garber (2003) interpret the reserve accumulation as largely motivated by the country's export promotion strategy. Can we find supporting evidences of the mercantilist policy being adopted by the monetary authority of an economy? One way to address this question is by evaluating whether there are evidences of systematic interventions by the monetary authority to keep the local currency undervalued.

Applications of different exchange rate models have also become more popular in late 1990s with the adoption of euro in 1999, and the emergence of transition economies in the Central and Eastern Europe. Employing different models of equilibrium exchange rate determination, Koen, Boone, Serres and Fuchs (2001), Maeso-Fernandez, et.al. (2002) and Detken, et.al. (2002) explored what can be learnt from analysing the historical behaviour of the euro, and examined the fundamental determinants driving the euro. Acknowledging the small sample set of observations, most of these studies constructed a series of 'synthetic' euro rate by calculating a trade-weighted average of the currencies of eleven countries comprising the euro land. Taking the analyses a step further, Stein (2002) looked at how membership expansion would affect the equilibrium real value of euro.

In the case of the euro, there have also been numerous research interests in examining the fluctuations of the currencies of transition economies in recent years. Egert, et.al. (2006) conducted a comprehensive survey on equilibrium exchange rates looking at currencies of Central and Eastern Europe. A wide range of policy concerns which may affect the movements of the local currencies and contribute to the degrees of misalignment were discussed, including high current account deficit, the Dutch Disease phenomenon, membership of exchange rate mechanism (II) (and potentially euro), enterprise restructuring and implication of productivity catch-ups.

Right from the start of the Bretton-Wood Agreements, the search for an appropriate exchange rate regime has remained a contentious one, with many on-going debates in areas of international/open macroeconomics. To generate comparative

[1] Those studies include Husted and MacDonald (1998 and 1999), Rajan and Siregar (2002), Rajan, Sen and Siregar (2004), Lim (2000 & 2002) and Montiel (1997).

analyses on the benefits and costs associated with the different regimes, it is often necessary to first estimate the equilibrium exchange rate and to measure misalignment of a local currency under different exchange rate regimes.[2] To further illustrate the above, the next paragraphs look into the issues of trade and inflationary implications of rigid exchange rate regimes.

Should Southeast Asian economies which are mostly equally integrated and dependent on both the US and the Japanese economies, adopt a rigid bilateral exchange rate policy against the US dollar? Or should the economies peg their currencies to the yen? Rajan, Sen and Siregar (2004) found that the soft-US dollar pegging exchange rate policy adopted by the Thai government during the pre-1997 crisis period has largely kept the local currency in equilibrium against the US dollar but at the expense of massive and persistent misalignments of the baht against the yen. The large deviation from the equilibrium rate against the yen has been responsible for the country's significant bilateral current account deficit against the Japanese economy, especially in mid-1990s.

The choice of an exchange rate regime may also have direct consequences on the general price level in the economy. Studies have shown (theoretically and empirically) that interventions by the monetary authority to keep the level of real exchange rate below its "equilibrium" rate (i.e. at an undervalued level) are inflationary. Calvo, Reinhart and Vegh (1995) and Siregar (1999) have looked into these issues in a number of Latin American countries (namely Brazil, Chile and Colombia) and Indonesia, respectively. A more recent study conducted on a number of East Asian economies (Indonesia, South Korea and Thailand), Goo (2006) found that an exchange rate regime which led to an undervalued (overvalued) currency, has indeed, been inflationary (deflationary).

3. Real Exchange Rate: Measurement and Definition

Before any estimation of equilibrium exchange rate being conducted, it is vital that we understand different possible measurements of exchange rate. Studies on equilibrium exchange rates have dealt with a wide range of nominal, real, and effective exchange rates. As will be elaborated in this Section, one measure of exchange rate may capture movements of the exchange rate associated with shocks from the local economy, while other measurements incorporate both internal and external factors. As briefly mentioned in the introduction, depending on what policy issues or research questions we wish to address, more than one exchange rate measure may need to be calculated. Ultimately, different constructions of exchange rate measurements will likely lead to different estimates of the equilibrium rates.

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[2] Another stream of studies looking at the different choices of exchange rate regimes has often focused on the degree of exchange rate volatilities and of speculative attacks. Similarly, Rahmatsyah *et, al*. (2002) and Siregar and Rajan (2004) found that the real and nominal rates of the baht and the rupiah against the yen were significantly more volatile that their rates against the US dollar. Applying one of the most common index of exchange market pressure to Indonesian rupiah, Malaysian ringgit and the Thai baht, Pontines and Siregar (2007) have shown that the number of reported incidences of speculative attacks are highly sensitive to the choice of anchor currencies.

3.1 Basic Construction of Real Exchange Rate

With the exception of a small number (mostly applying the concept of purchasing power parity) where nominal exchange rate is being considered, equilibrium exchange rate models largely refer to real rate (Q), which is given as nominal exchange rate (E) multiplied by foreign price level (P^*) and divided by domestic price level (P).

$$Q = \frac{E.P*}{P} \qquad (1)$$

The nominal exchange rate here is expressed as units of domestic currencies per unit of foreign currency. Hence, a rise in (E) and (Q) implies a depreciation of nominal and real exchange rate of the local currency, respectively.

A couple of arguments have commonly been pushed forward as rationales for the adoption of real, instead of nominal, exchange rate in estimating equilibrium exchange rate.

- Decisions of consumers on consumptions and producers on productions are largely made based on real 'terms', not a nominal ones (Stein and Allen (1995)).
- Most countries, especially developing and transition economies, adopt a rigid exchange rate policy, where the nominal exchange rate is fixed or pegged against one or a basket of major world currencies. Thus, a very limited set of analyses can be derived from the movements of the nominal exchange rate.[3]

It is also worth noting here that a large number of studies have considered real effective exchange rate (Q^{REER}), instead of bilateral real exchange rate. The construction of the real effective exchange rate can easily done by modifying Equation (1):

$$Q^{REER} = \sum_i \beta_i \frac{E.P_i^*}{P} \qquad (2)$$

$$\beta_i = \frac{EX_i + IM_i}{EX + IM} \qquad (2b)$$

Where: (P_i^*) is the price of foreign country (i). β_i is a trade weight assigned to each real exchange rate of domestic currency against foreign currency (i). The trade weight is calculated as the share of trade with country (i) in the overall total trade of domestic economy. EX and IM denote export and import, respectively. In general, a number of top major trading partners' currencies, with their total trades making up at least around 75 percent of total trade of the domestic economy, are included in constructing the real effective exchange rate.

[3] Some have also argued that the nominal equilibrium rate can be calculated once the real equilibrium rate is found.

3.2 Tradable and Non-Tradable Price

The next task is to examine the role of price in determining what the real exchange rate actually measures. To do so, it is necessary to decompose the general price level into its tradable and non-tradable components. The decomposition of the price level will prove to be very helpful in explaining the transition from an early approach of Purchasing Power Parity to more recently developed exchange rate models.

In the logarithm forms, both the domestic price (p) and foreign price $(p*)$ can be expressed in the following ways.

$$p = \beta.p^{NT} + (1-\beta).p^{T} \quad (3a)$$

$$p^{*} = \beta^{*}.p^{*NT} + (1-\beta^{*}).p^{*T} \quad (3b)$$

Where: (p^{NT}) and (p^{*NT}) are domestic and foreign non-tradable price, respectively. (p^{T}) and (p^{*T}) are domestic and foreign tradable price, respectively. (β) and $(1-\beta)$ are shares of non-tradable and tradable sectors for the domestic economy, while (β^{*}) and $(1-\beta^{*})$ are shares for the foreign economy. (Note: small letters refer to logarithms hereafter).

Substituting Equations (3a and 3b) into Equation (1), we can redefine real exchange rate as:

$$q = \left(e + p^{*T} - p^{T}\right) - \left((1-\beta)\left(p^{NT} - p^{T}\right) - (1-\beta^{*})\left(p^{*NT} - p^{*T}\right)\right) \quad (4)$$

There are a number of important points which ought to be briefly underlined from Equation 4 as they will have numerous implications on our attempts to estimate and analyse the equilibrium rate.

- Equation 4 suggests that the fluctuations of real exchange rate movements are potentially driven by two different sources: the real exchange rate of tradable goods $\left(e + p^{*T} - p^{T}\right)$, and the ratio of the domestic to the foreign relative prices of non-tradable and tradable goods $\left((1-\beta)\left(p^{NT} - p^{T}\right) - (1-\beta^{*})\left(p^{*NT} - p^{*T}\right)\right)$.
- Different measurements of the real exchange rate may inevitably capture different "definitions" and estimates of the equilibrium exchange rate for a same currency. For instance, the construction of Equation (1) using consumer price indices (CPI) should allow us to study movements of the real exchange driven by changes or shocks occurring in both non-tradable and tradable sectors. If, however, we are only interested in examining the movements of the real exchange rate as only driven by the tradable sector of the economy, then the use of unit value of export indices (or producer price indices (PPI)) would be more appropriate.
- Movements in the real exchange rate have also often been analysed for the rates of appreciation (and determinants of those changes) in terms of the relative competitiveness of an economy *vis a vis* another country. Driver and Westaway

(2004) for instance suggests the use of unit labour costs to focus on the cost competitiveness of an economy on one hand, and the adoption of the unit value of export indices, on the other, to measure competitiveness of tradable sector of an economy.

- The weights assigned for each sector of the domestic economy may likely be significantly different from those of the foreign partner (i.e. $\beta \neq \beta^*$). More importantly, this weighting scheme reflects the overall structure of the economy. Understanding the structure of the economy and the weight assigned for various sectors of the economy should, therefore, be a prerequisite to generate in-depth analyses of the sources of exchange rate movements and the forces driving the equilibrium exchange rate.
- The role of the price level and how it is determined, both in the local and foreign market, is also critical in estimating the equilibrium exchange rate. The presence of regulated or administered prices has been shown to influence the size of misalignment (the gap between the equilibrium and the actual rates) and, also the rate of convergence (from the spot misaligned rate to the equilibrium estimate).
- In a nutshell, depending on the underlying theories and/or the empirical constructions, different models of exchange rate determination may easily generate different real equilibrium rates for the same currency. Some capture the equilibrium rate for the tradable sector only, while other models incorporate shocks coming from both sectors (trade and non-tradable) in calculating their equilibrium rate.

4. Purchasing Power Parity

Since purchasing power parity (PPP) theory underlies much of modern literature on exchange rate determination, the focus of this Section is to expose its basic concepts. More importantly, we hope to highlight potential shortcomings of PPP, both theoretically and empirically, as these well known limitations have become the sources of motivations for the development of more recent models of equilibrium exchange rate.

4.1 The Concepts

This concept of PPP is formalised in a number of works by Cassel (1916 and 1918). To understand the basic argument that gave rise to the PPP rate, a proposition known as the law of one price (LOP), which provides a building block to variations of PPP, should first be elaborated. The LOP claims that under assumptions of no impediments to international trade and capital flows (such as tariff barriers and capital controls); with both domestic and foreign economies operating at full employment level in a market based price system, identical goods (i) sold in different countries must sell for the same price (expressed in the same currency).

$$P^i = P^{*i}.E \qquad (5)$$

The concept of PPP generalises the LOP proposition and asserts several important claims.

- The first is that the general price level of a basket of similar products in different countries will always be equalised when they are measured in a common currency (a concept known as the absolute PPP) ---as illustrated in Equation 6.

$$P = P^{*}.E \tag{6}$$

In other words, the fundamental notion of the PPP theory claims that price levels determine the equilibrium exchange rate (Equation 7). Given *everything else unchanged*, a rise in the local price level should raise E^{PPP}, i.e. a depreciation of the local currency.

$$E^{PPP} = \left(\frac{P}{P^{*}}\right) \tag{7}$$

- Second, the PPP real exchange rate is always constant and equals to one. This can easily be shown by substituting Equation (7) to Equation (1) and solving for the real exchange rate (Q).
- Given the basic assumption of price rigidity in the short-run, the PPP is often referred to as the long-run equilibrium exchange rate. In the short-run, the prevailing nominal exchange may, however, deviate from the PPP rate. This deviation is often considered as "under" or "over" valuation of the domestic currency. If $\left(\frac{E}{E^{PPP}}\right) > 1$, the local currency is undervalued. An overvaluation takes place when $\left(\frac{E}{E^{PPP}}\right) < 1$.

4.3 Theoretical and Empirical Support for PPP

There are a number of potential limitations with the basic concepts of PPP in capturing sources of shocks or changes to both nominal and real equilibrium exchange rate. Some are largely due to its underlying concept and others to its basic assumption.

- The Law of One Price may not hold due a number of possibilities such as trade impediments (existence of tariff and non-tariff barriers), capital controls, and administered pricing policy. Brunetti, Kisunko, and Weder (1997) and Tybout (2000) have argued that price control is among the regulatory problems facing production lines in less developed economies. Other studies have also found that deviations from the LOP are significant, volatile and persistent, even across highly traded and sophisticated manufacturing goods (Rogoff (1996)). The nominal exchange rates are, in short, far more volatile than relative prices. A large number of studies have also found that the deviations from the LOP are either

simply reflecting the nominal exchange rate movement or highly correlated with exchange rate movements.[4]

- Even when LOP holds, changes in shares or weights (β or β^*) of different sectors or products may lead to the failure of the PPP (Equation 4). In the long-run, due to a series of factors, consumers may acquire different preferences and producers choosing different products to maximise their profits. The weights (β or β^*), thus, vary overtime in both domestic and foreign markets and may diverge significantly. As a result, the PPP in this case is a flawed measurement as the baskets of goods being compared may consist of completely different products ---violating the assumption of identical basket of goods discussed early.
- The existence of non-tradable goods also undermines the validity of the PPP concept. This can be easily shown by the breakdowns of Equation 4. By its definition, the real PPP $\left(q^{PPP}\right)$ exchange rate only captures the real exchange rate for the tradable sector $\left(e + p^{*T} - p^{T}\right)$. Hence, q^{PPP} fails to capture shocks in the non-tradable sector, resulting in persistent divergences between $\left(q^{PPP}\right)$ and the prevailing real exchange rate level $\left(q\right)$. The share of the non-tradable sector has been found to be significant among transition and developing economies (Egert, *et.al.* (2006)). Supporting the finding of Egert, *et.al.* (2006), Duval (2002) examined tradable and non-tradable real exchange rate movements of 14 OECD economies and found that long-run PPP rates cannot be verified for the tradable rates. Furthermore, the study also found that there is a very high correlation between the real exchange rate for tradables and non-tradables.
- Reverting to the measurement issue, the presence of non-tradable products often explains the gap between the consumer prince index (CPI) and the producer price index (PPI) or the wholesale (WPI)-deflated real exchange rate.[5] By testing the internal relative price stability by regressing the CPI on the PPI, Frenkel (1981) has shown that the singular influence of traded-nontraded-goods prices in one country influence the rejection of the PPP. Breuer and Lippert (1997), however, demonstrated that the PPP is influenced by the joint, cross-country relationship between traded- and nontraded-goods prices, and not necessarily, by the singular influence of traded- to nontraded-goods prices in one country (pg. 195).
- Differences in the relative productivities of tradable versus non-tradable sectors of the local and foreign economies also result in the failure of the PPP. This is often referred to as the Balassa-Samuelson (B-S) effect. A lower productivity rate in the tradable sector of the developing economy (home economy) than of the developed (foreign) economy implies that the local currency is often undervalued. To illustrate this point, we borrow the analysis of Egert (2003). The relative price of a two-sector (non-tradable and tradable) neoclassical framework is a function of

[4] Refer to Isard (1977), Richardson (1978), Giovanni (1988) and Knetter (1989, and 1993) for some of these findings

[5] The PPI and WPI contain a much higher proportion of traded goods than CPI.

average labour productivities (output (Y) per labour (L)) and labour shares of each sector ((l^T) and (l^{NT})) of both sectors, as shown in Equation 8.[6]

$$\frac{P^{NT}}{P^T} = \frac{l^{NT}}{l^T} \cdot \frac{Y^T / L^T}{Y^{NT} / L^{NT}} \tag{8}$$

Transforming equation (8) into its log form, we can derive the following relationship.

$$p^{NT} - p^T = \alpha + \left(a^T - a^{NT}\right) \tag{9}$$

Where the constant term (α) contains $\log(l^{NT})$ and $\log(l^T)$. A similar relative price ratio as a function of relative labour productivity rate in two sectors ($\left(a^T\right)$ and $\left(a^{NT}\right)$ or often referred to as a dual average labour productivity) can also be generated for the foreign economy. Assuming for simplicity that $\left(\beta = \beta^*\right)$ and substitute Equation (9) for both local and foreign economy to Equation (4), a link between the real exchange rate and the dual average labour productivity at home and abroad can be established.

$$q = \alpha' + \left(e + p^{*T} - p^T\right) - \left((1-\beta)\left(\left(a^T - a^{NT}\right) - \left(a^{*T} - a^{*NT}\right)\right)\right) \tag{10}$$

The Balassa-Samuelson critique of PPP can easily be shown using Equation 10. The presence of productivity gaps between the local and foreign sectors will lead to the failure of the PPP analysis. The currency of a domestic economy (usually a developing economy or a transition economy), with a smaller rate of productivity gap than that of the foreign economy ($\left((1-\beta)\left(\left(a^T - a^{NT}\right) - \left(a^{*T} - a^{*NT}\right)\right)\right) < 0$), would likely be undervalued $\left(q > q^{PPP}\right)$.

- Furthermore, as productivity in the tradable sector of the home economy (developing economy) catches up with that of its counterpart in the developed (foreign) economy, one would expect that the real exchange rate of the local economy to experience *trend* appreciation. Increase in the productivity rate of the tradable sector would lead to an increase in wage rate in both sectors (trade and non-tradable), due to the assumption of high labour mobility, and thus raise the income level in the domestic economy. Prices of non-tradables will go up with stronger demand, commonly referred to as structural inflation. As a result, the prevailing real exchange rate appreciates. However, as tradable prices (p^T and p^{T*}) are exogenously determined in the world market, the rise in

[6] The relative price of Equation 8 is derived from a profit maximisation process of a two sector-neoclassical framework with perfect capital mobility and with the interest rate assumed exogenous. The step by step derivation to achieve the Equation can be obtained from Egert (2003).

productivity will not necessarily affect $\left(q^{PPP}\right)$, thus creating a widening gap between $\left(q^{PPP}\right)$ and (q).

- Summing up the discussions above, the Balassa-Samuelson (B-S) positively links movements in relative income with the overall price level in an economy, which may not be necessarily captured by the PPP approach. Based on a simple logarithmic regression over 100 observations, Rogoff (1996) confirmed the propositions of the B-S, and hence at the same time, highlighted another potential shortcoming of the PPP.[7]
- Little support for the PPP was found in early studies (Krugman (1978) and Frenkel (1981)). The presence of stickiness in nominal prices, a term coined by a seminal work by Dornbush (1976) on the overshooting exchange rate, led to a popular argument that temporary deviations from the PPP should take place in the short-run, but one would, at least theoretically, expect convergence in the long-run. Frankel (1986) argued that one way to deal with a sufficiently slow convergence to purchasing power parity rate was to have observations over a long period span. Employing annual data for the dollar/pound exchange rate for the period 1869-1984, Frankel was able to reject evidences supporting the PPP. His estimate suggests that the expected number of years for a PPP deviation to decay by 50 percent (a half-life) is 4.6 years. More studies in the 1990s found further evidences of a mean reversion in the real exchange rate over long-horizon data sets. They found a half-life of PPP deviations of anywhere between 2.5 years to 4.7 years.[8]

5. The Monetary Approach to Equilibrium Exchange Rate

5.1 Basic Concepts

In addition to the list of potential shortcomings and flaws behind the concepts and constructions of the PPP, its lack of power to explicitly identify other determinant factors of equilibrium exchange rate, beyond the relative prices and the productivity gaps between tradable and non-tradable sectors, has further motivated researches in this area. A direct extension of the PPP is the Monetary Approach to exchange rate determination, establishing a theoretical link between the nominal exchange rate and a set of monetary fundamentals. As it assumes the flexibility of price and incorporates the concept of PPP, the Monetary Approach can too be characterised as a long-run concept of equilibrium exchange rate.

The monetary approach is built on a number of well-established theoretical concepts. Under a money market equilibrium condition, a log-linearised basic money demand (function of income and nominal interest rate) is set equal to an exogenously determined money supply:

[7] Other studies have, however, found a mix of evidences for the B-S effect. Please refer to De Gregorio, Giovannini, and Krueger (1994), De Gregorio and Giovannini, and Wolf (1994), and De Gregorio and Wolf (1994).

[8] Refer to Abuaf and Jorion (1990), Lothian and Taylor (1996) and Glen (1992).

$$m_t - p_t = \alpha_1 y_t - \alpha_2 i_t \quad (11)$$

$$m_t^* - p_t^* = \beta_1 y_t^* - \beta_2 i_t^* \quad (12)$$

Variables (m_t) and (m_t^*) denote domestic and foreign money supply, respectively. Similarly, (p) and $(p*)$ are domestic and foreign price level, respectively. (i) represents domestic nominal interest rate, and $(i*)$ is the foreign nominal interest rate. ($\alpha_1, \alpha_2, \beta_1$ and β_2) are coefficient parameters, where all of them are theoretically expected to be greater than zero.

Solving for price level in both Equations (11) and (12), and subtracting the foreign price from the domestic one, the following relationship can easily be derived.

$$p_t - p_t^* = (m_t - m_t^*) - \alpha_1 (y_t - y_t^*) - \alpha_2 (i_t - i_t^*) \quad (13)$$

For the sake of simplicity, it is assumed that $(\alpha_1 = \beta_1)$ and $(\alpha_2 = \beta_2)$. Under the assumption of long-run flexible price and that the PPP condition holds a reduced form, the monetary approach of exchange rate determination can be constructed:

$$e_t = p_t - p_t^* = (m_t - m_t^*) - \alpha_1 (y_t - y_t^*) - \alpha_2 (i_t - i_t^*) \quad (14)$$

The monetary approach simply states that the movement of nominal exchange rate (e_t) is driven by the excess money supply, output and nominal interest rate in the local economy relative to their levels in the foreign economy.

5.2 On-going Empirical Debates

Despite its theoretical appeal, early empirical works on the model have not been conclusive to say the least. A seminal work by Meese and Rogoff (1983) found that a naïve random walk model outperforms a number of available exchange rate models at that stage, including the monetary model. Mark (1995) and Chinn and Meese (1995), on the other hand, showed a more promising result and concluded that monetary fundamentals are useful in predicting U.S. dollar exchange rates during the period starting early1980s to1990. However, Berben and van Dijk (1998) and Berkowitz and Giorgianni (2001) criticised Mark (1995) for relying on the strong assumption that there is a stable cointegrating relationship between nominal exchange rates, relative money supplies, and relative outputs.

Other studies have also found little evidence of cointegration between the monetary fundamentals and the nominal exchange rate. Chinn and Meese (1995) and Baillie and Pecchenino (1991) have not found conclusive evidence of a cointegration relationship among the nominal exchange rate and monetary fundamentals. Despite finding some evidences of cointegrating relationship among the relevant variables,

Cushman (2000) came to conclude that US-Canadian data do not support the monetary model.

A couple of more recent studies have, however, shown more supporting evidences for the monetary model. Applying the panel cointegration testing on a set of quarterly data from quarter 1, 1973 to quarter 1, 1997 of 19 countries, Mark and Sul (2001) have found a cointegration relationship among the nominal exchange rate, the relative outputs and the relative money supplies. The study concluded that the forecasting power of the model is significant. Applying to datasets of 14 industrialised countries, Rapach and Wohar (2002) tested the monetary model and found some weak evidences of a cointegrating relationship among the variables for eight of those countries. However, as in the case of empirical works in favour of the PPP, their finding was based on a very long span of data dating back as far as the late nineteenth century.

6. The Fundamental Equilibrium Exchange Rate (FEER)

6.1 Underlying Theoretical Concepts

With the objective of capturing other factors, beyond just monetary variables in determining movements of equilibrium exchange rate, the concept of fundamental equilibrium exchange rate (FEER) was largely credited to the works of Williamson (1985 and 1994). A number of basic features of FEER are worth highlighting.

- Its basic concept is based on the notion of both internal and external balance. Williamson (1994) defined FEER as a real effective exchange rate that simultaneously secures internal and external balances for a given number of countries at the same time.
- Internal balance is reached when the economy is at full employment output and operating in a low inflation environment.
- External balance is characterised as a sustainable balance of payment position over a medium-term horizon, ensuring desired net flows of resources and external debt sustainability. A minimum criteria for external balance is that the current account balance has to be sustainable (Williamson (1994), p. 180).
- Abstracting from the short-run cyclical and speculative forces in the foreign exchange market, the FEER approach focuses more on "economic fundamentals" which are expected to persist in the medium-term horizon. Hence, in its basic form, it is considered as the medium-run equilibrium exchange rate model.
- The FEER is considered as a normative measure of equilibrium exchange rate as it is the rate that will be consistent with ideal economic circumstances of macroeconomic balances (both external and internal balances as discussed above).

In contrast to the PPP approach, the FEER approach recognises that the equilibrium real exchange rate will vary across time. A number of factors guide the trajectories of the FEER.

1. The first one is related to the determination of potential output growth associated with low inflation in both domestic and foreign economies. Acknowledging potential gaps in productivity growths of Balassa (1964), the FEER will have to appreciate and depreciate over time as countries grow at different rates (Williamson (1994)).
2. The second is to address what would be considered as a sustainable current account level. Maintaining current account balance at a targeted rate requires the local currency to appreciate and depreciate accordingly.
3. In short, the trajectories of the FEER would be derived from the changes in the real effective exchange rates that ensure domestic and foreign output to be in their paths to achieve the targeted current account balance (or the desired current account balance).

Given the difficulties to simultaneously achieve these three goals of finding potential outputs, sustainable current account, and consistent trajectories of FEER to achieve the two previous goals, it is usually assumed that internal balance (i.e. full employment output operating in a low inflation environment) will automatically be satisfied when the external balance (sustainable and desired current account level) is achieved. Thus, as shown by Clark and MacDonald (1998) and MacDonald (2000), the most popular method of generating a FEER involves two sequential steps.

The first is to identify the external balance equation by simply equating the current account balance (CA) to capital account balance (KA).

$$CA = -KA \tag{15}$$

Following a standard definition, the current account is a sum of net trade balance and returns of net foreign assets $(nfar)$. The net trade balance (ntb) is assumed to be a function of full employment outputs of the local and foreign economies, i.e. $(\bar{y}_d)$ and $(\bar{y}_f)$ respectively, and the real effective exchange rate (q).The return of net foreign asset is also influenced by the movements of the exchange rate. An accumulation of net foreign liabilities (negative net foreign asset) will have to be financed. It will be necessary under this condition for the currency to depreciate to improve trade balance and improve the net foreign asset position. Key relationships for the FEER approach can, therefore, be encapsulated in the following equations.

$$CA = ntb + nfa \tag{16a}$$

$$ntb = \delta_0 + \delta_1 q + \delta_2 \bar{y}_d + \delta_3 \bar{y}_f \tag{16b}$$

Where: $\delta_1 > 0,\ \delta_3 > 0, \text{and}\ \delta_2 < 0.$

$$nfar = f(q) \tag{16c}$$

In most application of the FEER approach, the level of equilibrium capital account over the medium term $(\overline{KA})$ is exogenously determined.[9] It is important to underline here that $(\overline{KA})$ excludes speculative capital flow. Combining Equations (15 and 16a-16c) and the basic assumptions discussed above, the following medium-term balance of payment equation can be generated.

$$CA = f\left(q^{REER}, \overline{y}_d, \overline{y}_f\right) = -\overline{KA} \qquad (17)$$

In short, there are three vital elasticities to be calculated under the FEER approach, namely, the elasticity of the current account to domestic activity $(\overline{y}_d)$, to foreign output $(\overline{y}_f)$, and to the real (effective) exchange rate (q^{FEER}).

Given full employment outputs of the local and foreign economies, $(\overline{y}_d)$ and $(\overline{y}_f)$ respectively, and that of medium-term equilibrium $(\overline{KA})$, the level of real exchange rate to be derived from Equation (16) is the FEER. Hence, the last step is to solve Equation (16) for (q^{FEER}), which will ensure that we achieve a sustainable current account or the path to achieve the "macroeconomic (internal and external) balance".

$$q^{FEER} = f\left(\overline{KA}; \overline{y}_d; \overline{y}_f\right) \qquad (18)$$

6.2 Critical Notes and Empirical Findings

Several analyses and discussions on the FEER approach are worth noting.

- The assumption of a sustainable current account or external balance has been criticised for "an extra layer of judgment being imposed when calculating trade elasticity" (MacDonald (2000)). Considering the simplest form of current account (Equation 16a), where the $(nfar)$ component is assumed to be zero or relatively small when compared to (ntb), the real exchange rate elasticity on imports must, therefore, be close to the real exchange rate elasticity on exports under the assumption of "external balance". In another word, the estimated trade elasticity of the FEER is effectively close to zero (Goldstein and Khan (1985) and Wren-Lewis (1992)).
- Relying too much on the trade elasticity may generate an inaccurate estimate of the FEER trajectory. A depreciation of the real exchange rate of the domestic currency would not only lead to an improvement in (ntb), but also should increase $(nfar)$. If the FEER only captures the changes in (ntb) and assume the impact on $(nfar)$ to be exogenously determined, then the size of required real

[9] See Williamson (1994) and Bayoumi *et.al*. (1994).

exchange rate appreciation may be overestimated.[10] Hence the size of currency misalignment estimated by FEER is likely to be an inaccurate one.

- Bayoumi, et.al. (1994) and Driver and Westaway (2004) further highlighted the analytical limitation introduced into the FEER due to possible fluctuations on the returns of net foreign assets. To illustrate this point, we quote the following from MacDonald (2000) - "..assume that in the initial period the current exchange is at the FEER level and internal and external balances are obtained. The actual exchange rate then depreciates in the next period, thereby improving the current balance and improving the net foreign asset position. The latter, in turn, implies that in future periods, the real exchange rate which is consistent with medium-run capital accumulation will no longer be the FEER; in particular, the FEER needs to appreciate to squeeze out the effects of net accumulation. This hysteresis effect is a necessary consequence of viewing the exchange rate as a medium run concept" (page 39).[11]
- As discussed, speculative capital flows are extracted from the medium-run capital account of the FEER approach. It has proven, however, to be a complex task to distinguish structural and speculative components of capital flows. Standard approaches are relying on a number of econometrics techniques to decompose a time-series variable into a temporary or speculative component from the more permanent share.[12]
- The assumption of exogenous speculative capital flow (driven largely by interest spreads and exchange rate fluctuations ---also known as the interest parity condition) is an attractive feature of the FEER approach as it simplifies the estimating steps. However, for the speculative flow assumption to hold, it requires that the interest rates to have settled into long-run equilibrium levels. This certainly places a lot of restriction on monetary policy.
- Given its strong set of basic assumptions (some of which are highlighted above), Wren-Lewis (1992) notes that the FEER is 'a method of calculation of real exchange rate which is consistent with medium-term macroeconomic equilibrium'. That is to imply that the FEER approach does not embody a theory of exchange rate determination. It is assumed that a divergence of the prevailing exchange rate from the FEER will set in motion forces that will bring the spot rate to the FEER. The approach used in the estimation of the FEER provides us with a medium-run equilibrium rate. However, the nature of the convergence process from the short-run/actual rate to the equilibrium rate is not specified (MacDonald (2000)). We will look into this issue of 'transition' and 'moving equilibrium' concepts when we examine the Behavioral Equilibrium Exchange Rate (BEER) and the Natural Rate of Exchange (NATREX) models.

[10] Obstfeld and Rogoff (1995) showed a simple correlation between changes in the real exchange rates and changes in the net foreign asset position. It is important to acknowledge here that correlation does not imply causation.

[11] The term "hysteresis" captures the notion that different equilibrium values may not be independent of the dynamic adjustment paths toward them (Bayoumi, *et.al.* (1994).

[12] This decomposition issue will be discussed more thoroughly when we examine the Permanent Equilibrium Exchange Rate (PEER) model.

7. The Desired Equilibrium Exchange Rate (DEER)

Given its normative assumptions of what would be the level of "internal and external balance", captured here especially by the size of targeted sustainable current account, it has been suggested that the equilibrium real effective exchange rate derived from the FEER approach be called "desirable" or desired equilibrium exchange rate (DEER) (Bryant (1983). In their work on the DEER, Bayoumi, *et.al.* (1994) further claimed that the calculated medium-term DEER equilibrium exchange rate is consistent with, and necessary for achieving "desired" positions of internal and external balance (Figure 1). The authors specified the medium-term horizon as "the period needed for output to return to potential and for changes in competitiveness to be reflected in trade volumes, which would appear to be in the range of four to six years" (page 23).

As a close variant of the FEER, the calculation of DEER methodically follows that of the FEER approach, whereby three estimates of current account elasticities (with respect to domestic output, foreign output and real exchange rate) must be solved. Given its construction, the estimates of the DEER can vary depending on the choices of assumptions regarding positions of internal and external balances, which will likely have impacts on the underlying elasticities. For instance, to calculate the DEERs for major economies in 1970, Bayoumi *et. al* (1994) assumed that the targeted current account surplus was equal to one percent of GDP.[13] Similarly, different assumptions on currency preference shifts may affect the trade balance and, therefore, the estimates of key elasticities listed earlier. Likewise, the adoption of trade balance *vis a vis* current account balance would also affect the underlying elasticities. In a nutshell, the choices of assumptions or policy targets would eventually lead to changes in the level of the DEER.

As in the case of the FEER, different estimates of the DEER are often calculated to generate a set of equilibrium exchange rates under different economic circumstances and policy choices. Therefore, this approach has proven to be a very useful policy tool in estimating different equilibrium exchange rates under varying sets of hypothetical policy current account/external balance targets.

8. The Behavioural Equilibrium Exchange Rate (BEER)

8.1 Basic Approach

In attempts to further extend the FEER approach, the BEER approach tries to explain the behaviour of the exchange rate by considering the origins of cyclical and temporary movements of the real exchange rate and also by taking the given values, not necessarily at the full employment values, of the fundamental determinants of the real exchange rate. Hence, the underlying assumption of macroeconomic balance of the FEER approach is noticeably absent under the BEER approach.

[13] The one percent of GDP current account surplus target was chosen as it was the stated objective of the U.S. Administration during the Smithsonian discussion of appropriate parities for exchange rates of the major industrial countries.

To illustrate the general framework of the BEER approach, the following discussions are based on a number of early works on the BEER by MacDonald (1997) and Clark and MacDonald (1998).[14] The theoretical underpinning of the BEER approach, which would arguably allow for the short-run or temporary analyses of the real exchange rate, rests on the basic concept of uncovered interest rate parity (UIP):

$$E_t(e_{t+1}) - e_t = i_t - i_t^* \tag{19}$$

where $E_t(e_{t+1})$ represents the expected value of the nominal exchange rate in period (t) for period $(t+1)$. e_t is the nominal exchange rate at period (t), defined in terms of domestic currency per unit of foreign currency. Thus, a rise in (e) implies a depreciation of the local currency. (i_t) and (i_t^*) denote local and foreign nominal interest rates, respectively. The risk premium component is assumed to be absent in Equation (19), as the primary objective here is to provide a simple construction of the BEER approach of determining the equilibrium exchange rate (this assumption will be relaxed in the latter part of the paper).

Subtracting the expected inflation differential, $\left(E_t(p_{t+1}) - p_t\right) - \left(E_t\left(p_{t+1}^*\right) - p_t^*\right) = E_t(\Delta p_{t+1}) - E_t\left(\Delta p_{t+1}^*\right)$, from both sides of Equation (19), we can easily convert the nominal interest rate parity into the real interest parity.

$$E_t(q_{t+1}) - q_t = r_t - r_t^* \tag{20}$$

Where:

$$r_t = \text{domestic real interest rate} = i_t - E_t(\Delta p_{t+1}) \tag{20b}$$

$$r_t^* = \text{foreign real interest rate} = i_t^* - E_t\left(\Delta p_{t+1}^*\right) \tag{20c}$$

$E_t(q_{t+1})$ denotes the expected real exchange rate at time (t) for period, and q_t is the observed real exchange rate. (p_t) and (p_t^*) are the domestic and foreign price level, respectively, at period (t). $\left(\Delta p_{t+1} = p_t - p_{t-1}\right)$ and $\left(\Delta p_{t+1}^* = p_t^* - p_{t-1}^*\right)$ are the changes in domestic and foreign price level, respectively.

By rearranging Equation (20), the observed real exchange rate q_t can be represented as a function of the expected value of the real exchange rate $E_t(q_{t+1})$, and the current real interest rate differential.

$$q_t = E_t(q_{t+1}) - \left(r_t - r_t^*\right) \tag{21}$$

[14] There have also been a number of studies employing the concepts of BEER, such as OECD (2001), Detken, et.al. (2001), and Maseo-Fernandez, et.al. (2002).

Under the BEER approach, the unobservable expectation of the real exchange rate, $E_t(q_{t+1})$, is assumed to be determined solely by long-run economic fundamentals (Z_t).[15] In short, the BEER approach produces estimates of equilibrium real exchange rate $\left(q_t^{BEER}\right)$ which incorporates both the long-run economic fundamentals $\left(E_t(q_{t+1}) = f(Z_t)\right)$ and the short-run interest rate differentials.

$$q_t^{REER} = f\left(Z_t, \left(r_t - r_t^*\right)\right) \tag{22}$$

To illustrate the BEER approach further, Clark and MacDonald (1998) assumed three long-run determinant variables of vector (Z_t), namely terms of trade (tot), Balassa-Samuelson effect, i.e. the relative price of non-traded to traded goods (tnt), and net foreign asset (nfa).

$$E_t(q_{t+1}) = f(\bar{tot}_t, \bar{tnt}_t, \bar{nfa}_t) \tag{23}$$

The signs on the right hand variables suggest the signs of partial derivatives. In addition, Clark and MacDonald (1998) also added the role of the risk premium component to the uncovered interest parity, and the time-varying risk premium is assumed to be a function of the ratio between domestic and foreign government debt $\left(\frac{gdebt_t}{gdebt_t^*}\right)$. Combining information from Equation (22), Equation (23) and the risk premium component, the BEER real exchange rate is determined by the following set of economic variables:

$$BEER = f\left((r - r^*), tot, tnt, nfa, \left(\frac{gdebt}{gdebt^*}\right)\right) \tag{24}$$

Comparing Equation (24) of the BEER approach and Equation (18) of the FEER approach, a number of similarities and dissimilarities can be highlighted. First, unlike the FEER, the BEER approach is not a normative one. While the FEER considers "sustainable external balance" and "internal balance", the BEER, on the other hand, is the equilibrium rate consistent with the prevailing levels of economic fundamentals.

Second, the BEER takes into consideration short-run cyclical/temporary factors that may contribute heavily to medium-to-long-run movements of the equilibrium exchange rate. The adoption of interest rate parity allows the BEER approach to capture the sources of changes in the capital account which may then also affect the current account and the "behaviour" of the exchange rate. The basic FEER approach, in contrast, only captures the behaviour of the exchange rate driven by changes in the positions of external and internal balances.

[15] Due to the lack of theoretical foundation for selecting the fundamental variables, Stein (2002) considers this model as an empirical one.

Third, as will be further elaborated when we look at the Natural Rate of Exchange (NATREX) model, the introduction of debt stock (in addition to flow) as one of the determinant variables, allow the BEER to capture the long-run trajectories of the equilibrium exchange rate.

Fourth, the BEER may converge to the FEER in the medium-run, under economic conditions of full employment and sustainability, impacting on changes in the equilibrium exchange rate.

8.2 Estimating the BEER and Empirical Findings

Since the equilibrium rate is not an officially observable variable, a common empirical approach to estimate the BEER involves a series of steps. To illustrate this, we return to the BEER model as applied by Clark and MacDonald (1998).

- The first step is to estimate the long-run (cointegration) relationship between the prevailing real exchange rate and the set of short-run and long-run economic fundamentals listed in Equation (25).[16]

$$q_t = \alpha + \beta_0\left(r_t - r_t^*\right) + \beta_1 tot_t + \beta_2 tnt_t + \beta_3 nfa_t + \beta_4\left(\frac{gdebt}{gdebt^*}\right)_t \qquad (25)$$

- Second, using the coefficient parameters of each fundamental variable ($\hat{\alpha}, \hat{\beta}_0, \hat{\beta}_1, \hat{\beta}_2$ and $\hat{\beta}_4$), the BEER real exchange rate can be calculated.

$$q_t^{BEER} = \hat{\alpha} + \hat{\beta}_0\left(r_t - r_t^*\right) + \hat{\beta}_1 tot_t + \hat{\beta}_2 tnt_t + \hat{\beta}_3 nfa_t + \hat{\beta}_4\left(\frac{gdebt}{gdebt^*}\right)_t \qquad (26)$$

- The last step is to calculate the level of the misalignment rate, measured as the difference between the prevailing real exchange rate (q_t) and the BEER real exchange rate $\left(q_t^{BEER}\right)$.

Tackling the different policy issues which have been briefly discussed in Section 2 of this paper, a number of recent studies have adopted the BEER to examine the country cases of Central and Eastern European currencies. The IMF (1998), for instance, estimated the equilibrium real exchange rate for Slovakia. A number real exchange rate measurements were considered, including the CPI-based, PPI-based as well as unit labour cost-based. The share of public consumption and investment in GDP, the openness ratio (total trade over GDP), real wage to proxy productivity were the long-run fundamentals, while M2/GDP was considered as the short-run determinant. The study concluded that the current account deficit in a country is brought about by real

[16] Obviously, each of these variables must go through unit-root property test before the cointegration test in conducted on them.

overvaluation. Similar studies applying the BEER to European transitional economies, can be found in Egert (2004) and Egert, *et.al.* (2006).

A recent study by Goo (2006) applied both the NATREX and BEER to estimate the equilibrium real exchange rates of the Indonesian rupiah, Korean won and Thai baht over a period of two decades (1985-2004). The study constructed the wholesale price index (WPI)-based real effective exchange rate, CPI-based real effective exchange rate, real exchange rate against the yen, and real exchange rate against the US dollar. She found periods of misalignments (both over- and undervalued local currencies and with the application of the monetary model of inflation, the study also illustrated that an undervalued currency is inflationary and *vice versa*.

9. The Permanent Equilibrium Exchange Rate (PEER)

In our analysis of the BEER, we have indicated that the equilibrium rate is derived based on the prevailing levels of economic fundamentals. Hence, the misalignment rate captured from the steps above, is often referred to as the *current* misalignment rate. However, as the prevailing rates of economic fundamentals may arguably deviate significantly from the "sustainable level" or the "long-run/permanent" level, early studies have extended the analysis of the BEER by estimating the equilibrium level of exchange rate driven by the long-run sustainable levels of identified economic fundamentals. This equilibrium exchange rate is known as the Permanent Equilibrium Exchange Rate (PEER). The difference between the actual real exchange rate and the real PEER is referred to as *total* misalignment.

Decomposing each of the relevant variables into its temporary and permanent component is often one of the first critical steps to generate the PEER, which is missing from the BEER approach.[17] Others have applied decomposition testing on the BEER to generate the PEER. Techniques introduced by Beveridge and Nelson (1981), Clarida and Gali (1995), Stock and Watson (1998) and Gonzalo and Granger (1995) are some of the commonly used tools to disaggregate the non-stationary series into the permanent (the non-stationary part) and the temporary/stationary components.

Contrasting the current misalignment of the BEER and the total misalignment of the PEER should further identify different sources of misalignments. For policy makers for instance, it is relevant to understand whether the misalignment has largely been driven by temporary shocks or by permanent ones from one or more of the determinant factors. Illustrating the benefits of constructing the BEER and the PEER, Clark and MacDonald (2000) evaluated the real effective exchange rates of the US dollar, Canadian dollar, and the U.K. pound. For the U.S. and the Canadian dollars, they found that the BEER and the PEER move very closely together, implying only a very small temporary component. In

[17] For Clark and MacDonald (1998), the set of relevant variables includes $\left(q, \left(r - r^{*} \right), tot, tnt, nfa, \left(\frac{gdebt}{gdebt^{*}} \right) \right)$, as also posted in Equation (25).

contrast, the volatility of the UK pound appears to be driven by fluctuations of the permanent component of the real interest rate differential.

Another study applying both the BEER and the PEER is the Maeso-Fernandez, et.al. (2002) which evaluates the equilibrium rate of euro effective exchange rate over the period 1975 to 1998.[18] Applying the cointegration test to generate the BEER, and the Gonzalo-Granger decomposition, they discovered that the PEER is smoother (less volatile) than the BEER. Both indicate that the euro was close to the fundamental value in the 1970s and first half of the 1990s but undervalued in the first half of the 1980s.

10. The Natural Rate of Exchange (NATREX)[19]

10.1 Basic Definition and Underlying Framework

Stein (1994) defined the NATREX as the rate that would prevail if speculative and cyclical factors could be removed and unemployment is at its natural rate.[20] Hence, as in the case of the FEER, the basic notion of the NATREX follows closely the idea of the equilibrium exchange rate as introduced by Nurkse (1945). There are three basic foundations for the NATREX approach.

The first one is that the approach framework lies within the standard national income accounting equation:

$$I - S + CA = 0 \qquad (27)$$

where (I) is the desired investment, (S) the desired saving and (CA) the desired current account. The levels of desired saving and investment depend on the existing stock of capital, wealth, and net debt to foreigners.

Equation (27) captures the medium-run equilibrium when the economy is operating at capacity output and expectation about inflation is met ---which are similar to that of the FEER approach. The medium-run position is characterised by the following conditions, that:- a) the domestic securities market clear; b) cyclical and short-term speculative capital flows cancel out; c) any difference between investment and saving represents the excess flow of supply of tradable long-term securities. Hence, under these conditions, Equation (27) also captures the balance of payment equilibrium (the sum of capital and current account balance). The medium-run NATREX is the equilibrium rate consistent with the desired balance of payment equilibrium or the macroeconomic balance.

[18] The euro rate here is the synthetic rate based on trade-weighted of 12 major trading partners.
[19] This Section highlights different analyses of Stein (1994), Stein and Allen (1995), and Stein and Paladino (1998).
[20] Stein (1994) argues that if changes in reserves and short-term capital flows are included, then the balance of payment would "always balance, by definition" (pg. 134).

Second, Stein (1994) defines the fundamentals as the disturbances to productivity and social thrift (time preference of consumption/expenditure by household and government) at home and abroad, denoted by vector $(Z(t))$. The exogenously determined fundamentals will not only affect the desired investment, saving and current account, but will also influence the trajectory of the NATREX. $(Z(t))$ will affect capital formation, the rate of debt accumulation and also the interest rate. As desired saving and investment change, the NATREX rate will fluctuate accordingly (to new rates). In another words, the NATREX approach adds dynamics (i.e. changes in capital stock and debt) which then feed back into the macroeconomic balance. This feature allows the NATREX approach to look at the path of the exchange rate from the medium-term to the long-run equilibrium ---which is arguably missing under the previous models.

Lastly, the NATREX rate will converge to a static long-run rate when there is no further changes in the fundamentals (hence no changes also on the stocks of capital and debt).

Based on the basic frameworks discussed above, unlike the basic FEER approach, the NATREX is a moving equilibrium exchange rate, and the trajectory of the exchange rate can be decomposed into three components: the medium-run, the longer-run, and the steady state. For clearer illustration, the real exchange rate can be depicted as being in three different phases/ stages:

- The actual/spot rate: $q_t = q_t(k_t, F_t, \varepsilon_t : Z_t)$, which is the realised rate at time (t), given the stock of capital (k_t), stock of debt (F_t) and the presence of speculative capital flows. As discussed, the stocks of capital and debt are influenced by the changes in the fundamentals $(Z(t))$.
- The medium-run NATREX: $q = q(k_t, F_t : Z_t)$, which is affected by the changes in the stocks of capital and debt (due to changes in the fundamentals). However, unlike the spot rate, speculative flows do not influence the medium-run NATREX. Hence, this rate is also what is supposedly obtained by the FEER approach.
- In the long-run, the NATREX converges to a static long-run rate: $q^* = q^*(Z_t)$. This constant or stationary long-run real equilibrium NATREX is consistent with the PPP rate. Hence, the NATREX extends early models such as the PPP and the FEER by focusing its analyses on the periods when the fundamentals are not stationary and generating the trajectories of the exchange rate from the spot/short-term to the medium-run, and from the medium-run to the static long-run position.
- Based on the analyses above, the spot real exchange rate is, therefore, not necessarily an equilibrium rate, i.e. $q_t(k_t, F_t, \varepsilon_t : Z_t) \neq q(k_t, F_t : Z_t)$, and it can be decomposed into three phases of exchange rate movements and states (Equation 28):

$$q_t(k_t, F_t, \varepsilon_t : Z_t) = \{(q_t(k_t, F_t, \varepsilon_t : Z_t) - q(k_t, F_t : Z_t))\} + \{q(k_t, F_t : Z_t) - q^*(Z_t)\} + \{q^*(Z_t)\}$$

(Note: $\{(q_t(k_t, F_t, \varepsilon_t : Z_t) - q(k_t, F_t : Z_t))\}$ captures the trajectory from the spot rate to medium-run rate; and $\{q(k_t, F_t : Z_t) - q^*(Z_t)\}$ denotes the longer-run trajectory (from the medium-run equilibrium position to the long-run static equilibrium rate)).

- To illustrate the directions of the trajectories, let us consider the impact of an increase in government expenditure (social preference) in the medium-and long-term horizon. In the medium-run, the rise in government expenditure will increase aggregate demand, and cause an appreciation of the real exchange rate of the local currency. The strengthening of the local currency would, in turn, worsen the current account position through a possible deterioration in the net interest flows on foreign debt. In the long-run, a *depreciation* of the local currency is needed to stabilise net foreign assets.

10.2 Estimating the NATREX

The estimation of the NATREX raises two issues. The first is associated with the selection of the fundamentals that capture the shocks in productivity and social thrift (time preference). The second issue is on the testing procedures, i.e. between testing a single reduced form equation (much like the BEER discussed earlier) and estimating structural equations.

As expected, on the selection of the fundamental variables, productivity and social thrift/time preference are commonly considered the fundamental variables in all applications of NATREX. To capture productivity, some authors use the productivity of labour, measured by (GDP/total employment) while others adopt total factor productivity (Stein 2002). By definition, social thrift reflects the changes in total consumption (household and government) over GDP during the observation period. However, since household consumption is found to be stationary over a long-term span for some countries, only the ratio of government expenditure over GDP is considered as a proxy for social thrift (Stein and Paladino (1999), and Rajan and Siregar (2002)). As for the other fundamentals that may influence the evolution of capital and debt, their selection is highly influenced by the types of economies being considered, i.e. developing and developed economies.[21]

On the estimation steps, a large number of studies applying the NATREX use a single reduced form equation. A few studies, however, have conducted structural estimations of the NATREX, such studies on European currencies by Crouchy-Veyrac and Saint Marc (1997), Detken and Martinez (2001), Federici and Gandolfo (2002), Detken, et.al. (2002). Detken, et.al. (2002), for instance, estimated individual sets of behavioural equations for the NATREX approach, including the investment equation, the consumption equation (representing saving) and trade balance (current account). The

[21] The terms of trade, for instance, is often considered as one of the fundamental variables for the small open economy, as it is exogenously determined (MacDonald (2002), Rajan and Siregar (2002), and Rajan, Sen and Siregar (2004)).

study then breaks the estimation to look at two separate cases - the medium- and the long-term evolutions of the NATREX.

To evaluate the equilibrium rate of the US dollar against the G7 currencies for the post-Bretton Woods period, Stein (1999), on the other hand, adopted the more common approach of estimating a single reduced form equation, with two sets of fundamental variables, i.e. social thrift and productivity of domestic and foreign countries. Similarly, a study by van Eden, et.al (2001) estimated a number of reduced form equations of the NATREX (medium- and long-run rates) to analyse the movements of the real exchange rate of the Chinese Renminbi against the US dollar.

11. Brief Concluding Remarks

The increasing integration of the global capital market, brought about by the adoption of open capital accounts and facilitated by technological advances, has benefitted the world economy as a whole. It has also, at the same time introduced new challenges for the overall macroeconomic management . The incidences of financial and currency crisis and the frequency with which they occur over the past decade are the reminders of the risks these challenges come with. Under the present global economic environment, measuring the degree of misalignment and its fundamental determinants will increasingly be important elements for macroeconomic management of open economies. Needless to say, having the appropriate tools is imperative for meeting these mounting challenges.

This paper examines the underlying concepts and assumptions of commonly employed models of equilibrium exchange rate and, more importantly highlights their advantages and shortcomings. Based on these analyses, a number of general lessons can be derived.

- To start with, a clear definition and construction of the real exchange rate is needed to estimate the equilibrium rate appropriately and to analyse the factors thwarting the prevailing rate from converging to the equilibrium rate. In some cases, different exchange rate measurements may be needed to comprehensively deal with the relevant research questions or policy issues.
- The selection of the model(s) to be adopted should always be closely based on the scope of issues to be tackled.
- Given the strengths and weaknesses of the different models, it is generally highly recommended to apply a number of alternative models, instead of just relying on one particular model, as well as to consider the estimates as a "range" of equilibrium exchange rates. Furthermore, the availability of different estimates derived from various models should strengthen our understanding of the sources of exchange rate movements.

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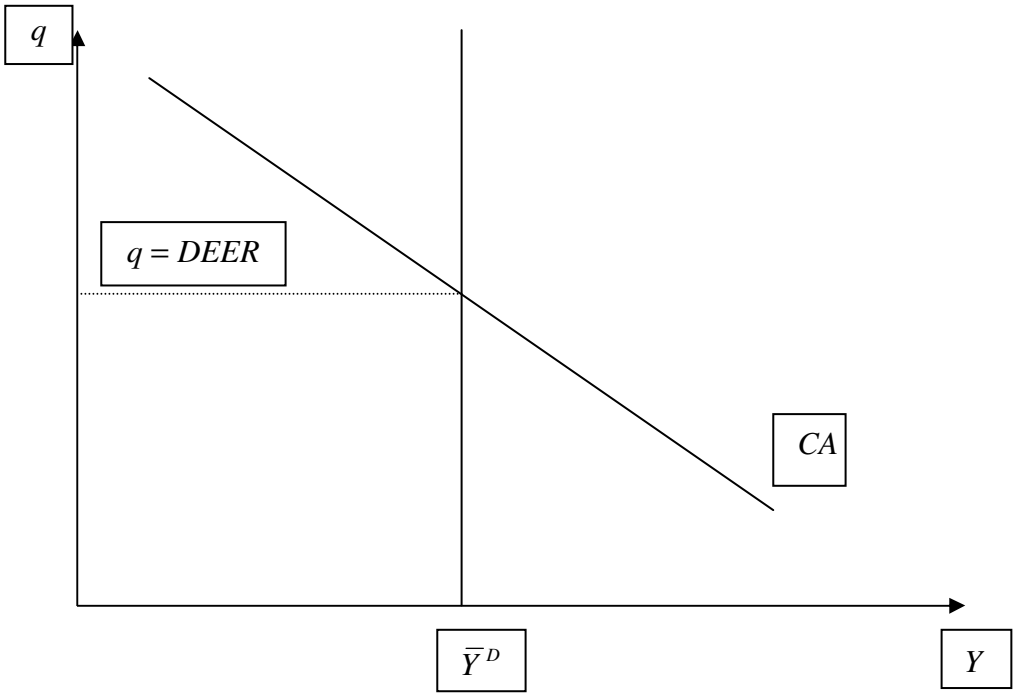

Figure 1: Desired Equilibrium Exchange Rate

The DEER real exchange rate level is the equilibrium real exchange rate consistent with both internal balance $\left(\bar{Y}^D\right)$ and external balance as captured by the current account (CA) line.